



Integrated Energy Systems Program Peer Review December 4, 2003



Cooling, Heating, and Power for Buildings

Reduce energy cost • Improve power reliability • Increase energy efficiency • Improve environmental quality

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Agenda

- Introduction
- Goals/Objectives
- Project Team/Partnerships
- Project Status
- Task Definition
- Project Status
- Milestones
- Project Risks
- Impacts of Project of DER Goals
- Summary

Project Goals/Objectives

- Develop and demonstrate through Laboratory Testing a Modularized “Plug and Play” Integrated System supplying:
 - Electricity
 - Hot Water
 - Chilled Water
- Optimize System to:
 - Improve Energy Efficiency to >70%
 - Reduce Engineering and Site Construction Costs
 - Reduce Risk
 - Increase Reliability
 - Eliminate Startup Issues
 - Financial Risk-Price Inflation
- Create Standard Line of Packaged Systems with a major engine manufacturer leveraging substantial distribution network and advanced engine developments (ARES).

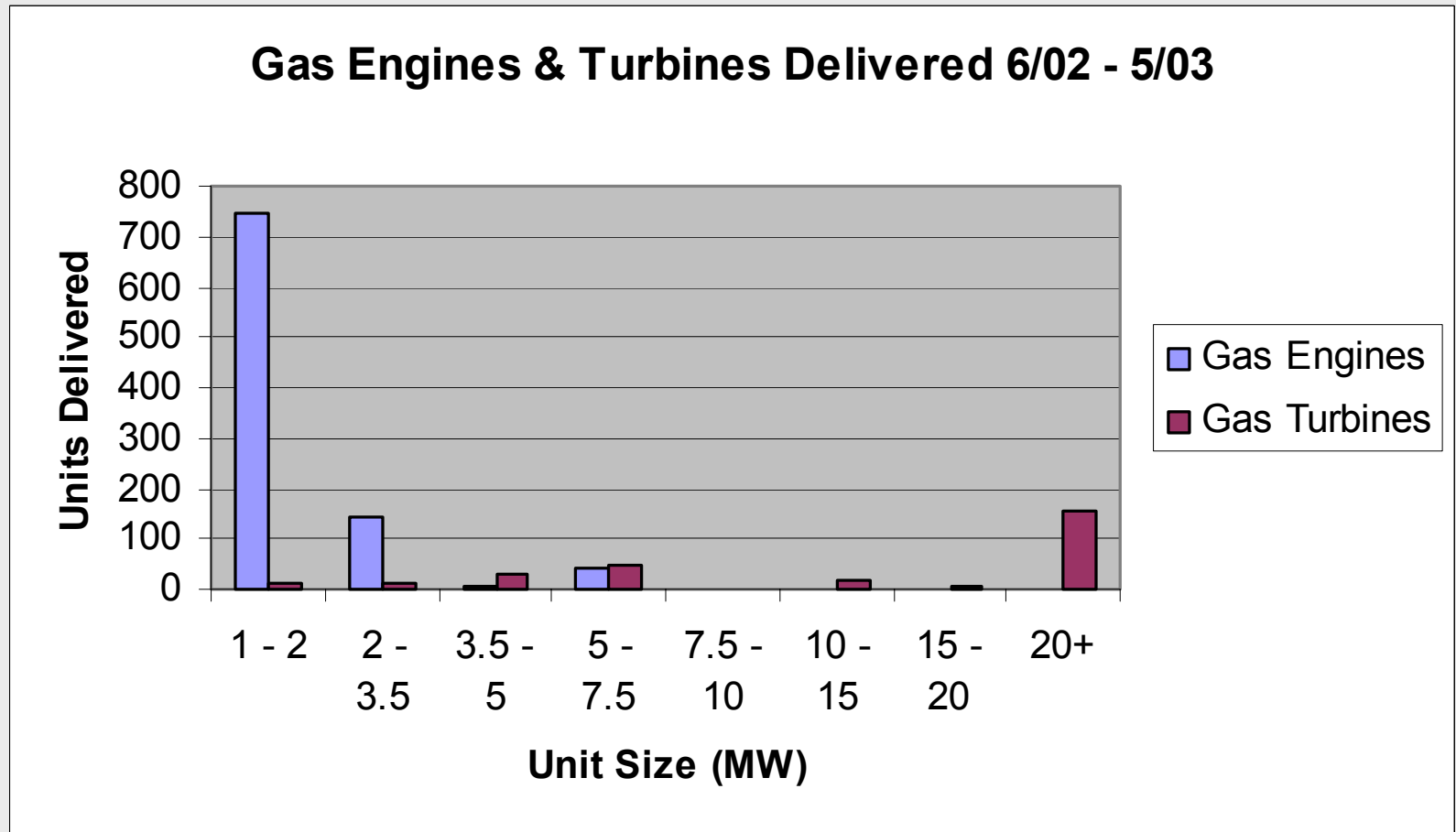
Why?

- **Customized Engineering Cost**
 - Larger Impact on First Cost/kW
- **One off designs lead to startup and operating issues**
- **Limited Qualified Designers/Installers**
 - Higher cost to compensate for risk
- **Customers don't buy engines they buy cars**
 - Or in our case CHP systems

Examples

- **GTI 2.5 MW - Not Packaged**
 - **ESCO Price - \$1300/KW**
 - **EPC Ballard - \$1000/kW**
- **MSI Cummins Packaged System, 1750kW**
 - **Installed for \$700/kW**
- **Smaller Systems cost more per kW**

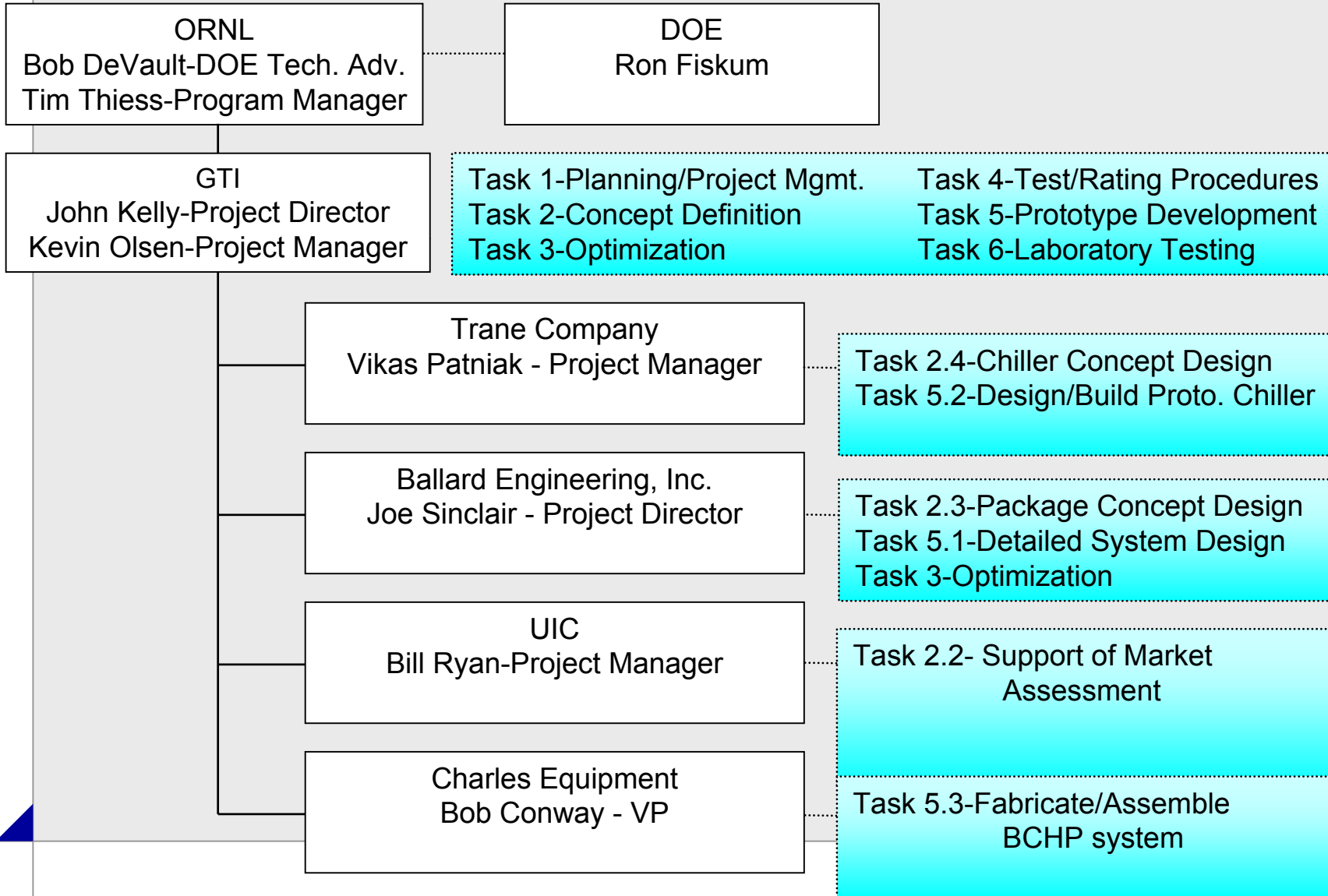
Why Engine Based System?



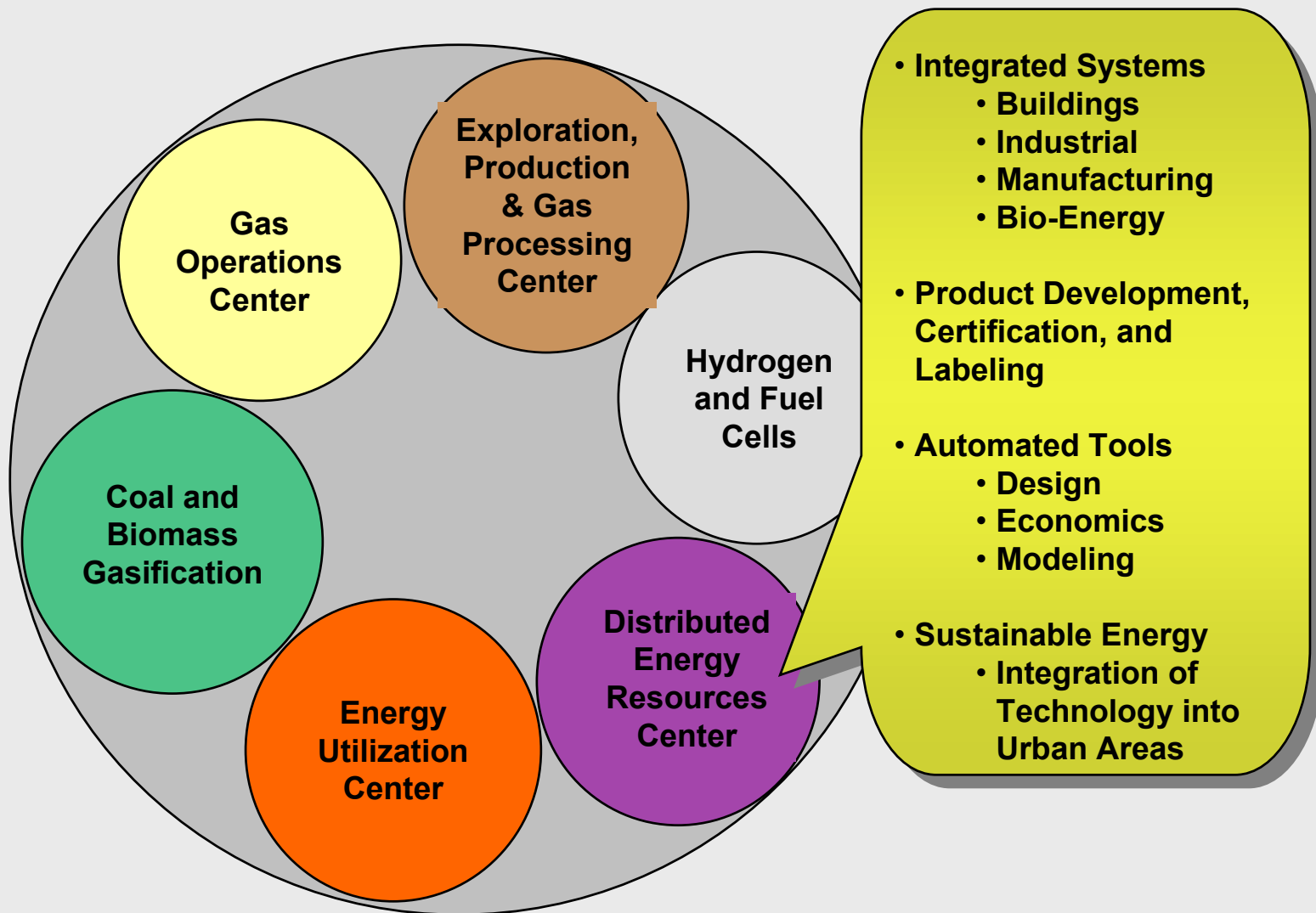
Project Team/Partnerships

- **Department of Energy (DOE)**
- **Oak Ridge National Laboratory**
- **Gas Technology Institute (GTI)**
- **The Trane Company**
- **Ballard Engineering, Inc.**
- **Charles Equipment Co. / Waukesha**
- **University of Illinois at Chicago (UIC)**

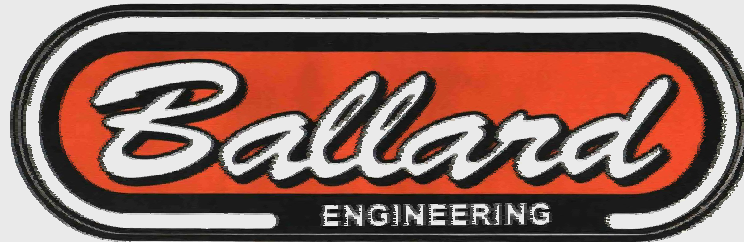
Project Organization



Gas Technology Institute

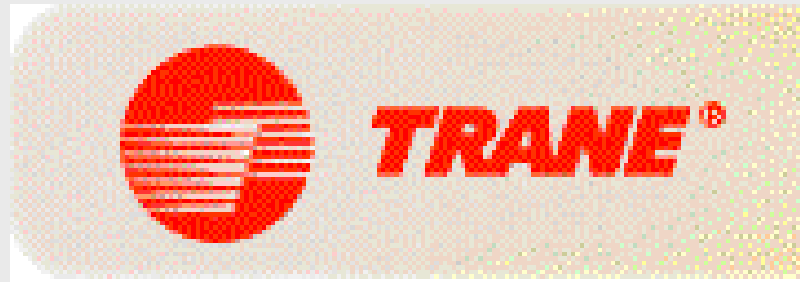


Ballard Engineering, Inc.



- Established in 1983, as a Division of Ballard Companies
- Turnkey Provider of CHP Plants for:
 - Hospitals
 - Institutions
 - Industrial Plants
- Experienced with Reciprocating Engine Generating Set and Absorption Chiller Integration
- Experienced in SCADA and Controls Integration

The Trane Company



- Leader in HVAC Systems for Commercial and Industrial Buildings
- Global Company - Trane has Offices, Service Operations, Joint Ventures and Manufacturing Facilities Around the World.
- In-House Absorption Technology Development Staff

Charles Equipment Co.



- Distributor of Waukesha engines
- Specializes in power systems for businesses, homes and municipalities for over 40 years
- Key member of Waukesha's distribution network



University of Illinois at Chicago (UIC)

- Mid-West CHP Application Center
- Industrial Application Center
- Marketing Studies
- Site Assessments
- Outreach Activities



Task Definition

Phase 1 Task Definition

Task 1 - Planning

Task 2 - Conceptual Design/ Market Assessment

Task 3 - Optimization

Task 4 - Testing Procedures/Standards Development

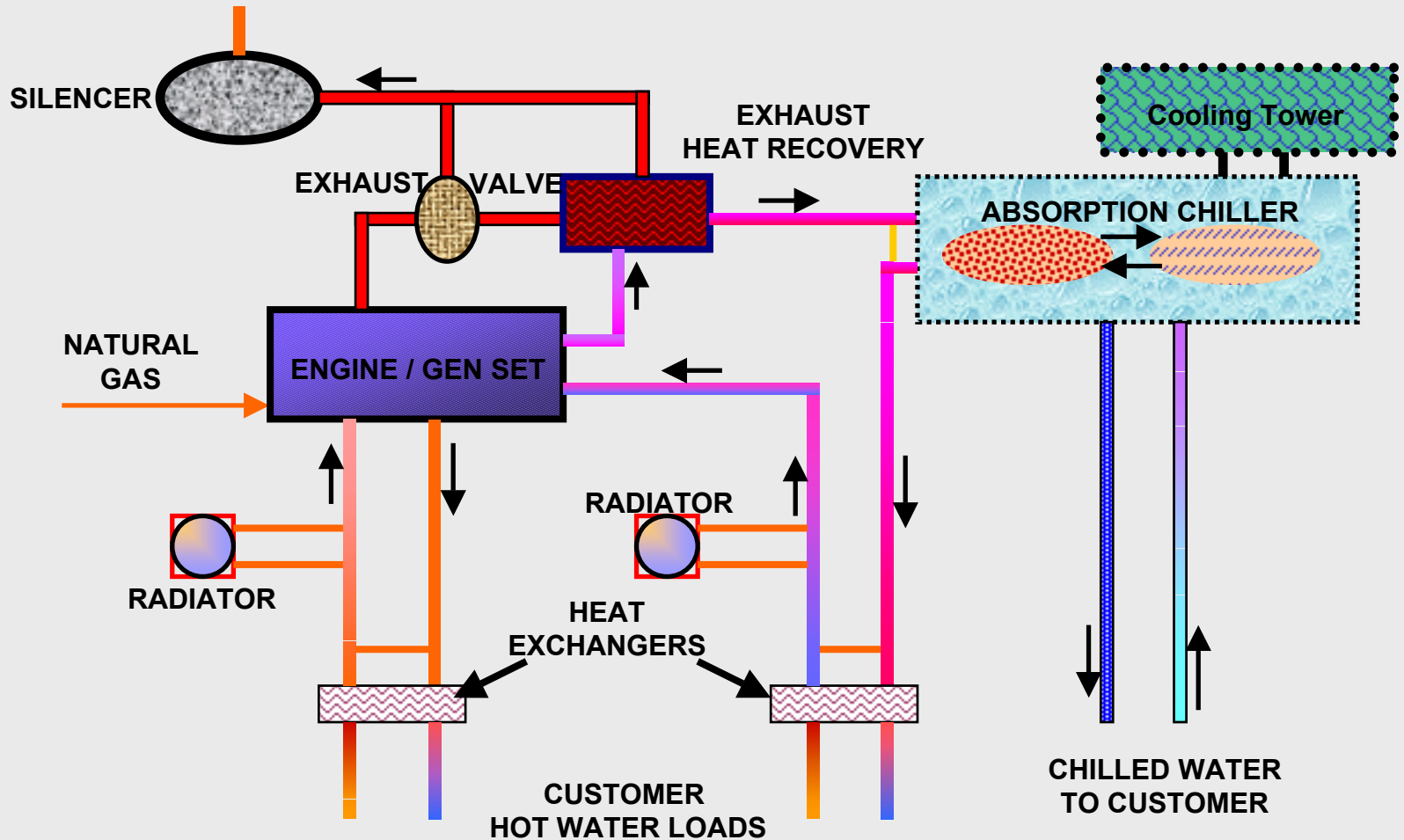
Task 5 - Detail Design and Fabrication

Task 6 - Laboratory Testing

Phase 2 – Commercialization/Demonstration

Project Status - Task 2

System Concept Development



Project Status – Task 2

Market Potential Assessment

Target Markets

| Segment | Existing Market | Notes |
|---------------------------------|-----------------|--|
| K-12 Educational Buildings | 11.6 GW | For Schools Over 400 kW Only |
| Medium Sized Medical Facilities | 10.9 GW | Covers Health Care Facilities from 50K to 150K SF, Dominated by Clinics Nursing Homes |
| Large Retail | 6.5 GW | Covers Retail Est. of 65,000+ SF NAICS Class 452: General Merchandise Only, Conventional Department Stores Discount or Mass Merchandise Department stores, National Chain Department Stores, Warehouse Clubs and Superstores |
| Large Hotel | 4.6 GW | >150 Room Facilities |
| Total | 34 GW | |

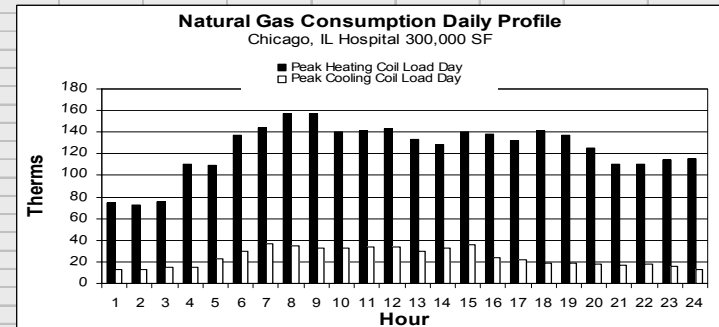
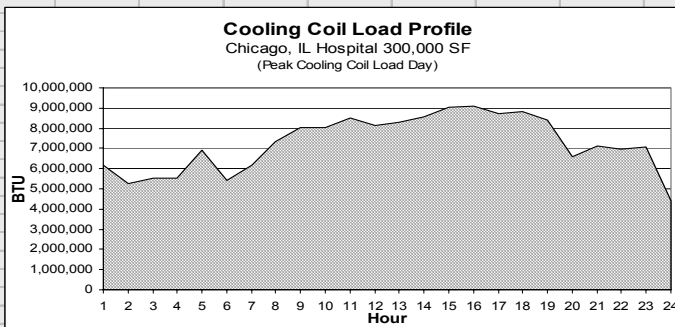
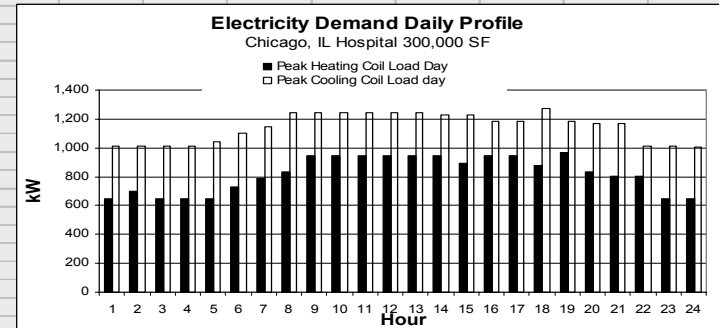
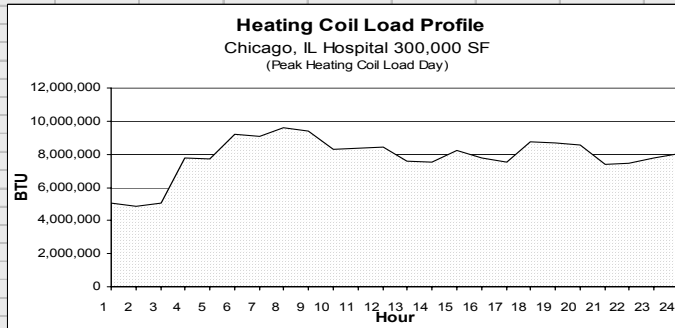
Project Status – Task 2

Market Potential Assessment

Development of Building Load Profiles

- Qty. (45) 8,760 hour building load profiles were developed using DOE2 version 1.E

Chicago, IL

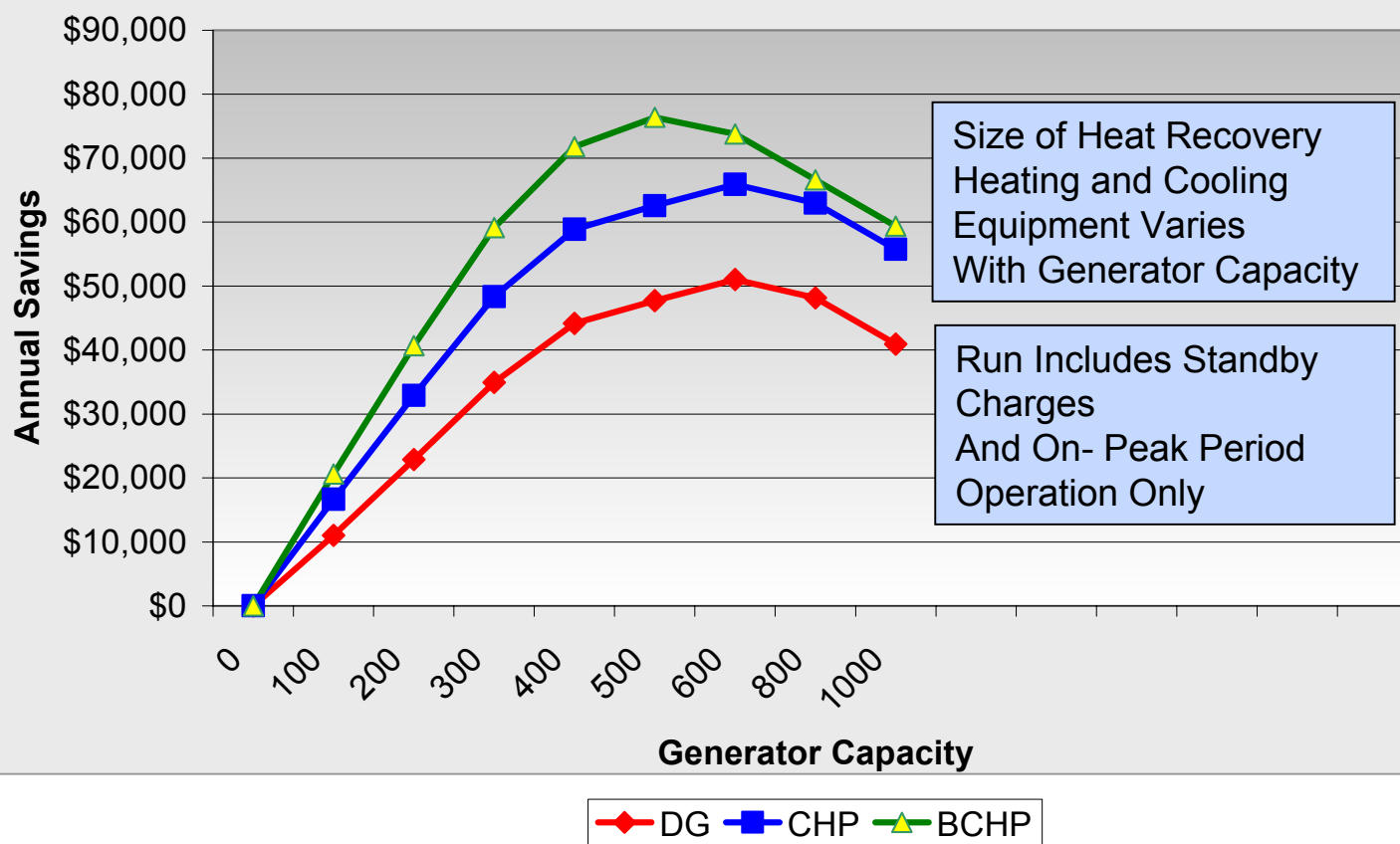


Project Status – Task 2 (cont'd)

Market Potential Assessment

BCHP Model Example Output Operating Cost vs. System Size

High School Load



Project Status – Task 2 (cont'd)

Market Potential Assessment

Summary

- Matrix of Applications/Locations Developed Based on Domestic Building Populations/Energy Consumption Intensity Data Defined
- Building Populations and Economics Form Basis of the Market Study
- 45 Target Building/Location Loads Profiles Developed
- Energy Rates for 9 Target Locations loaded into model
- Test Runs of The Simulation Model Have Been Performed
- Complete model runs of target building types in select regions will be completed following system testing using actual system performance. Economic analysis results to be used as basis for “Value Engineering” during Phase 2.

Project Status – Task 2 (cont'd)

Codes & Standards Review

Reviewed applicable Building Codes for select cities to develop searchable database for future product development

- Air Pollution Emissions
- Fire
- HVAC
- Plumbing
- Sound Emissions
- Electrical
 - Standby power
 - Grounding
 - Interconnect
 - Medium/High Voltage
- Hazardous Material
- Permit Fees

Designed system to meet most limiting codes, while considering overall economics.

Project Status - Task 4

Testing and Rating Procedures/Standards

GTI and Underwriters Laboratories currently developing a DE Performance Test Protocol in conjunction with SRI and ASERTTI.

■GTI/UL leading Laboratory Testing Protocol development and collaborating with SRI for Field Testing Protocol

■Status:

- Draft DE performance protocol complete
- Meeting with GTI/UL Stakeholder group consisting of Manufacturers, End Users, and Regulators scheduled for January 2004
- Test Protocol to initially cover Reciprocating Engine, Turbine, and Microturbine Generating sets and Integrated Energy Systems.

Project Status - Task 5

Detailed Design & Fabrication (Absorption Chiller)

New Technologies

- Cycle *optimized* for low temp. input
- Falling-film generator
- Counter-flow generator and absorber
- Low-cost, high-effectiveness HX



Objectives

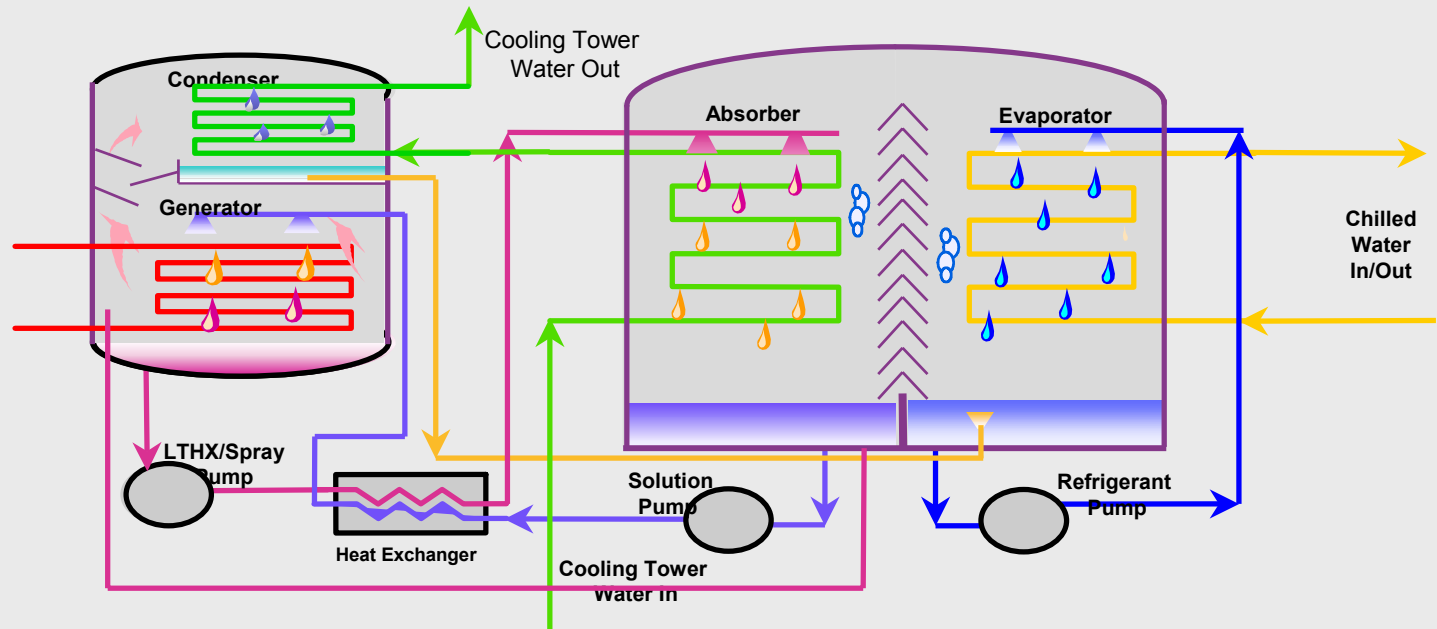
- Rapid access to emerging BHP system market
- State of the art design using proven Horizon^R technology
- Global product platform

Benefits

- Provides access to both emerging and established markets
- Low cost product
- Designed to interface with pre-engineered BHP package systems
- Fast track project

Project Status - Task 5 (cont'd)

Detailed Design & Fabrication (Absorption Chiller)



Design features

- Counterflow falling-film generator for optimal utilization of low temperature heat sources.
- Solution through heat exchanger pumped on both sides for compact design.
- Component platform same as Horizon II for ease of manufacturing and lowest product cost.

Project Status - Task 5 (cont'd)

Detailed Design & Fabrication (Absorption Chiller)

- **Component Requirements**
Comparison between Standard and Low-Source-Temperature Chiller
- **Tube bundle optimization for conceptual design**

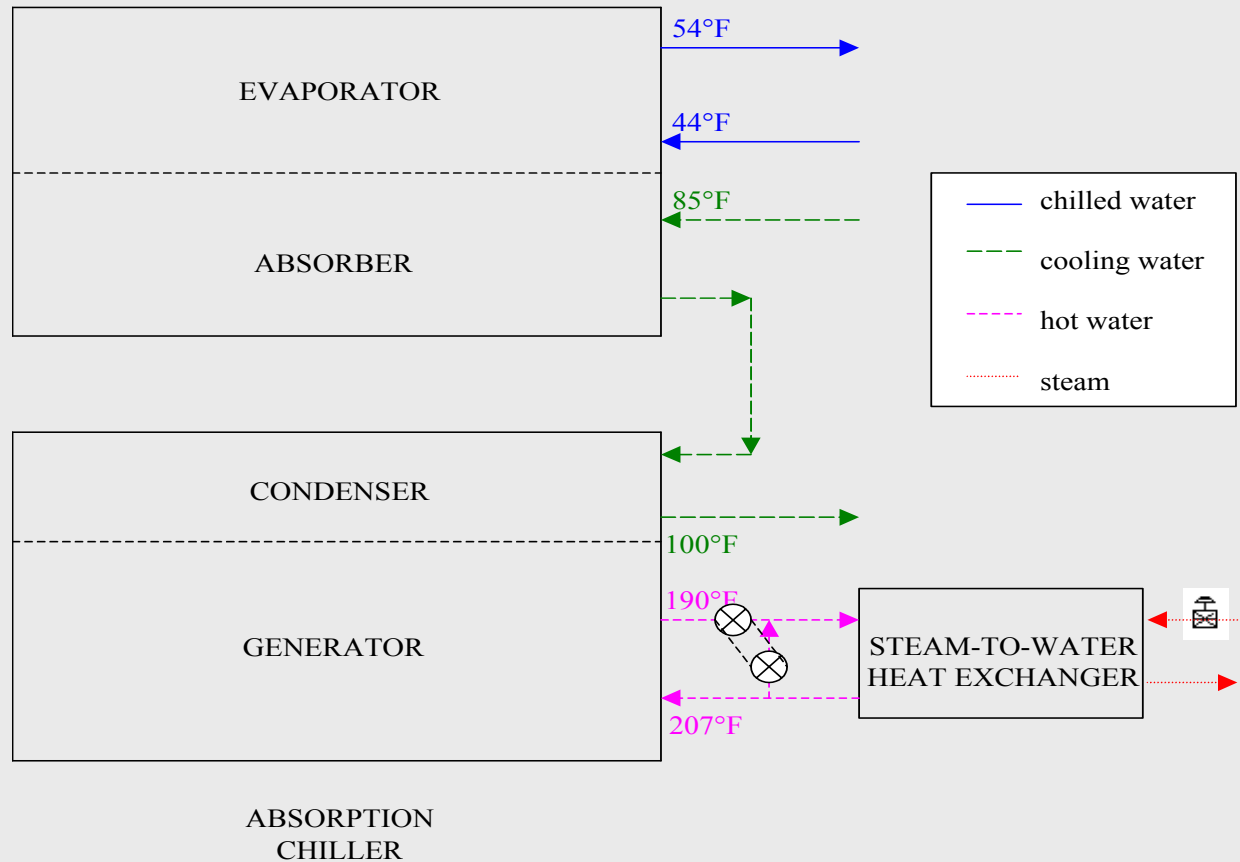
| Component | % Increase |
|------------|---------------|
| Absorber | 36% |
| Evaporator | 8% |
| Condenser | 31% |
| Generator | 115% |

- The generator needed the largest enhancement, but the absorber and condenser boosts were not insignificant either

Project Status - Task 5 (cont'd)

Detailed Design & Fabrication (Absorption Chiller)

Chiller Design Test Configuration



Project Status - Task 5 (cont'd)

Detailed Design & Fabrication (Absorption Chiller)

Summary

Work Completed

- Concept Development
- Design Optimization
- Production Drawing Package for Chiller
- Prototype Chiller Fabrication
- Test Chiller At Trane's Facility

Upcoming Work

- Support Integrated Laboratory Testing

Chiller delivered and awaiting final installation in system package

Project Status – Task 5 (cont'd)

System Detailed Design & Fabrication

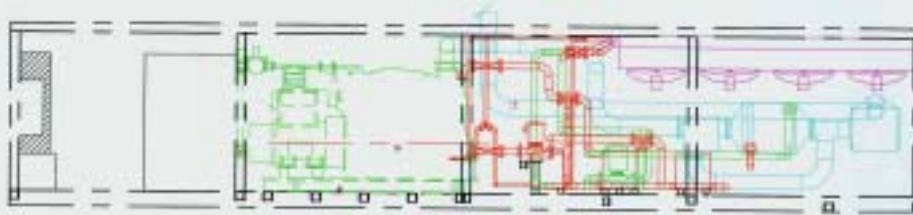
Innovative Design Concepts/Components

- Absorber Optimized for Lower Temperature Hot Water.
- Variably Controlled Hot Water Supply Temperature to
 - (a) Optimize chiller output
 - (b) Match facility hydronic temperature requirements
 - (c) Maintain standard engine maintenance schedule
- Newly released GE Zenith Entellisys Pro Paralleling Switchgear with built in SCADA, maintenance forecasting and notification, and historical trending. Standard load shed auxiliary contacts allow for flexibility in application (blackstart) with little modification.
- Pre-engineered modular insulated building enclosure.
- Equipment platform on a tubular frame to allow 100% portability



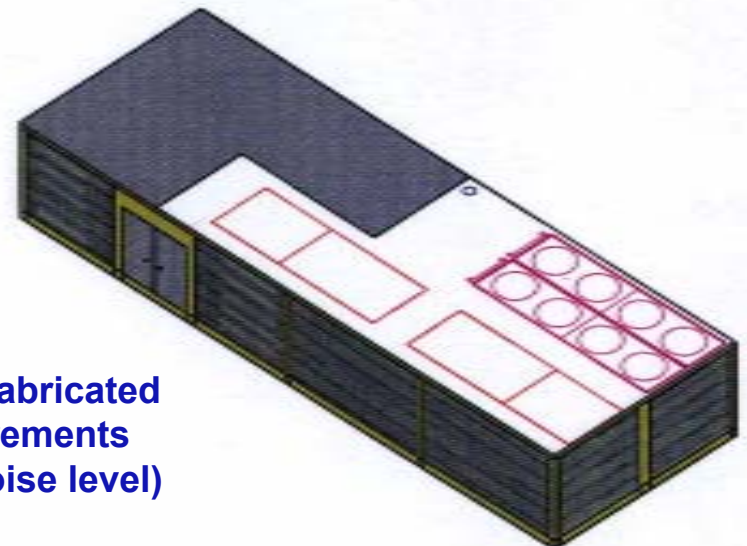
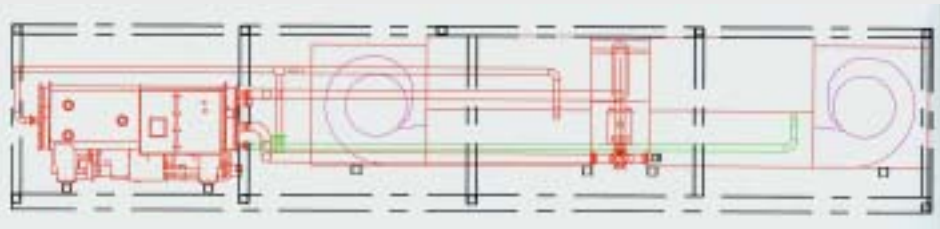
Project Status – Task 5 (cont'd)

System Detailed Design & Fabrication



Power/Heat Recovery Module

Chiller Module



**Prefabricated Structure Fabricated
to Customer Requirements
(i.e., color, texture, noise level)**

Milestones

Completed

- Codes and Standards Review
- Market Assessment
- Economic and Performance Model
- Absorption Chiller Design, Fabrication, Factory Testing
- System Conceptual Design and Optimization
- System Detail Design, Specification, Procurement

Remaining Tasks for 2004

- | | |
|---|------------|
| ▪ Fabrication of Modular System | March 2004 |
| ▪ Performance Test Protocol Development | May 2004 |
| ▪ Laboratory Testing of Modular System | June 2004 |
| ▪ Reporting | July 2004 |

Technical Barriers/Risks

Technical Barriers

- There are currently no Technical Barriers associated with development of the prototype system.

Risks

- Widespread deployment hampered by evolving electricity tariff under deregulation.
- Natural Gas price volatility.

Project Contributions

- The project is developing a highly efficient, cost effective system for a large market.
- The system will provide for the integration of future manufacturer and DOE sponsored development programs.
 - ARES
 - Switchgear & Controls
 - Thermally Activated Technologies

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Summary

- **Calculated system performance greater than the 70% System Efficiency.**
- **Project is on Budget.**
- **No Major Hurdles Identified or Anticipated throughout Phase 1**